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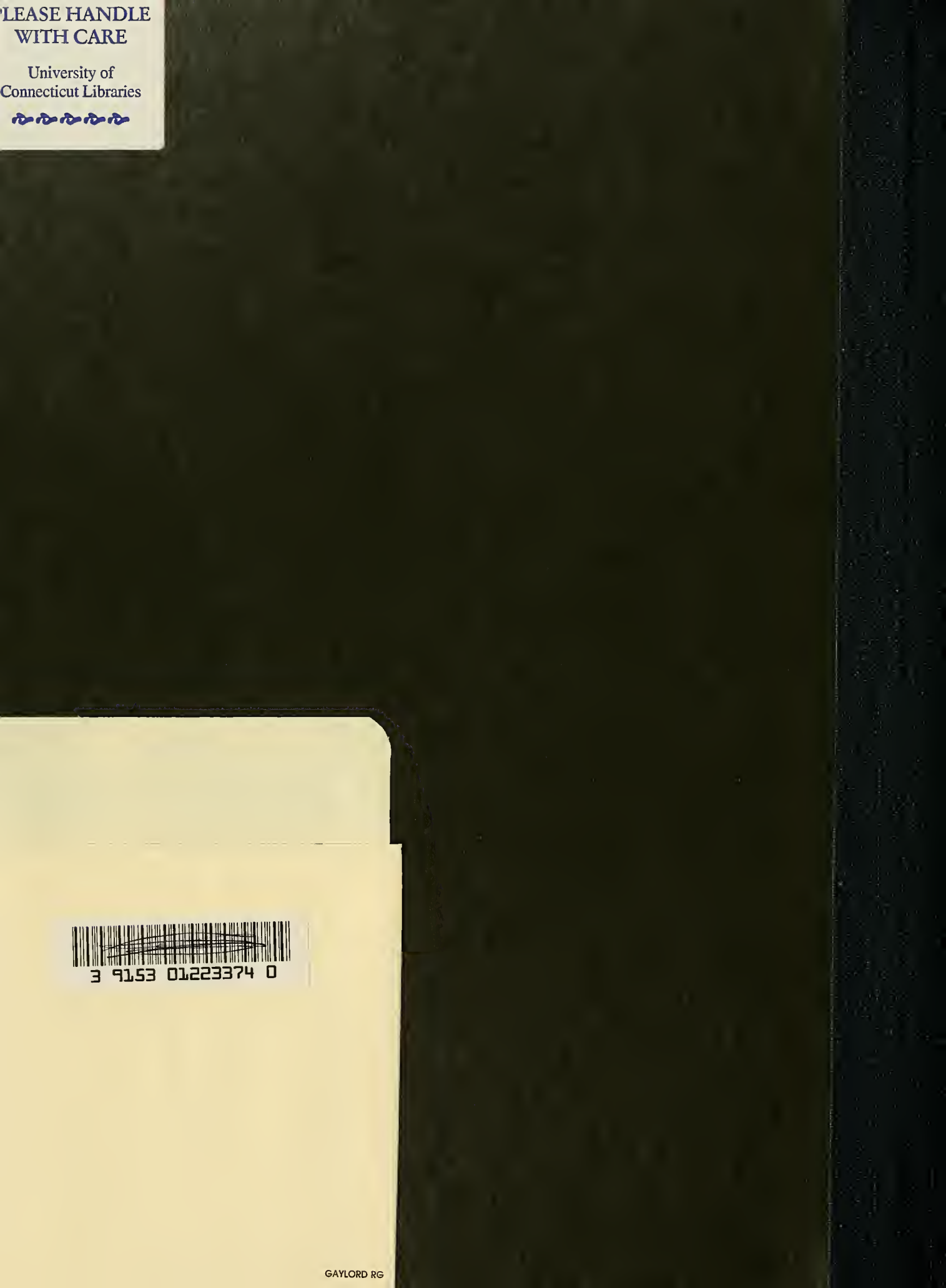

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The Connecticut Agricultural Experiment Station, New Haven

Chinese Cabbage and Pak Choi Trials 1988-1989

BY DAVID E. HILL

Bulletin 879

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SUMMARY

During 1988-1989, cultivar trials of Chinese cabbage and Pak choi were conducted in spring and fall at Mt. Carmel (loamy, upland soil) and Windsor (sandy terrace soil). In spring 1988, the average yield of five cultivars of Chinese cabbage was 20,520 lb/A at Windsor and 14,360 lb/A at Mt. Carmel. The 43% lower average yield at Windsor was attributed to moisture stress during early growth in the sandy soil. In 1989, a year of excessive rain, average yields of Chinese cabbage in spring at Windsor exceeded 16,500 lb/A in the first crop and 22,000 lb/A in the second crop with 25% of the plants bolting. At Mt. Carmel, average yields were two-thirds less with 60-100% of cultivars bolting. Premature flower induction was caused by persisting cold temperature in the saturated loamy soil. Blues, Kasumi and Two Seasons provided the highest yields and quality at both sites.

In fall 1988, the average yield of 12 cultivars of Chinese cabbage exceeded 27,000 lb/A at both sites. In fall 1989, the average yield of 12 cultivars in three plantings at Mt. Carmel were 16,980, 28,590, and 39,000 lb/A compared to 12,000, 16,980, and 18,240 lb/A at Windsor. The lower yields at Windsor were due to leaching of nutrients by excessive rainfall in the first crop and 22-43% of heads rotting in the second and third crops, compared to 5-11% at Mt. Carmel. Cultivars with high yield and quality in fall at both sites were Blues, Dynasty, Jade Pagoda, and Two Seasons.

In spring 1988, the average yield of three Pak choi cultivars was 19,500 lb/A at Mt. Carmel and 16,050 lb/A at Windsor. In fall, average yields of the same three cultivars increased to 24,500 lb/A at Mt. Carmel and 22,750 lb/A at Windsor. In spring 1989, average yield in two crops declined to 14,560 lb/A at Mt. Carmel and 13,160 lb/A at Windsor. In fall, 1989 average yield in three crops was 19,310, 17,650, and 18,610 lb/A at Mt. Carmel and 25,640, 8,700, and 13,575 lb/A at Windsor. Lower yield in spring 1989 compared to spring 1988 was due to leaching of nutrients by excessive rain and bolting losses. Lower yields in fall 1989 compared to fall 1988, except the first crop at Windsor, were due to losses from crown rot initiated during periods of heavy rain. Joi Choi and What-A-Joy Choi bolted less and the yields exceeded 16,500 lb/A in spring plantings and 23,000 lb/A in fall at both sites. Quality was excellent.

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Chinese Cabbage and Pak Choi

Trials 1988-1989

BY DAVID E. HILL

Local supermarkets have reported increased sales of Chinese vegetables in the last decade. It is not surprising that these sales coincide with the influx of immigrants from the Far East. Vegetables are staples in oriental cuisine and stir-fry cooking has become increasingly popular in the kitchen. Chinese cabbage, *Brassica campestris,* var. pekinensis, and Pak choi (bok choy, Chinese mustard cabbage) *Brassica campestris,* var. chinensis, are important vegetables grown in Asia where earliest reports of their use are from the fifth century A.D. (Yamaguchi 1983). Chinese cabbage forms a compact (Napa type) to elongated head (Michihli type) with light green crinkled leaves and white midribs. In Pak choi, a non-heading type, the light green to white petioles support dark green leaves and form a rosette. (The rosettes will be referred to as "plants" in this report.) Chinese cabbage has high nutritional value, containing substantial amounts of vitamin A (5,270 I.U.), vitamin B (total of 1.39 mg niacin, thiamin and riboflavin), and calcium (252 mg) per cup. Caloric value is low (Anon 1971).

Cultivar testing was started in 1988 with a single spring planting of seven Chinese cabbage cultivars and three of Pak choi. In fall, 11 Chinese cabbage cultivars and three of Pak choi were tested. In 1989 cultivar testing was expanded to 25 cultivars of Chinese cabbage and 11 of Pak choi. Serial planting was also initiated to determine the breadth of harvest and maintenance of quality.

In this bulletin, I report yields, quality and maturity of Chinese cabbage and Pak choi cultivars at Mt. Carmel and Windsor in the spring and fall of 1988 and 1989.

METHODS AND MATERIALS

Chinese cabbage and Pak choi trials were conducted at the Valley Laboratory, Windsor on Merrimac sandy loam, a sandy terrace soil with somewhat limited moisture holding capacity; and at Lockwood Farm, Mt. Carmel on Cheshire fine sandy loam, a well drained loamy upland soil with a moderate moisture holding capacity (spring crop) and Watchaug loam, a moderately well drained, loamy upland soil with moderate moisture holding capacity (fall crop).

Seeds for the first and second spring plantings were sown 2 weeks apart in a greenhouse maintained at 50-70 F. Four-week-old seedlings were moved to a cold frame for hardening 10 days prior to field planting. The seedlings were transplanted at 18 in. spacing in rows 36 in. apart to provide 9680 plants/A. Each planting consisted of five randomized blocks with six plants per cultivar in each replication.

Seeds for the three fall plantings were sown at 2-week intervals in a greenhouse and moved outside 2-3 days after germination. Four-week-old seedlings were transplanted in the field at the 5-7 leaf stage.

The seedlings were grown in Promix BX in 36-pot packs, each pot 2 5/8 x 2 1/4 x 2 5/16 in. Water soluble 20-20-20 fertilizer (1 Tbsp/gal) was added to the seedlings 1 week before transplanting.

Most mature heads of Chinese cabbage and Pak choi cultivars were harvested in one picking. Individual plants of some cultivars had delayed maturity and were harvested 7-10 days later. The heads were weighed and the quality judged for color, closure, compactness of head, and hollowness of stalk. The selection of cultivars for spring and fall plantings was based upon recommendations of seed companies. Unspecified cultivars were grown in spring and fall. Late-maturing cultivars of Chinese cabbage were not grown in the third fall crop.

Seeds were obtained from several domestic seed companies, some of whom specialize in imports from China, Japan and Korea. The varieties selected include representatives of several types of Chinese cabbage and Pak choi grown for summer and/or fall harvest. They are grouped as follows:

CHINESE CABBAGE

Napa type (barrel-shaped heads)
- Large--Blues, Dynasty, Winter Giant, Wintertime.
- Medium--Arcadia, China Express, China Flash, China Pride, Magica, Nagoda, Nerva, Springtime, Spring Triumph, Summertime, Two Seasons, Wong Bok

Globular type (round heads)
- Small--Early Top, Tropical Pride
- Miniature--Tropical Shot

Michihli type (elongated cylindrical heads)
- Large--Jade Pagoda
- Medium--Green Rocket, Monument, VGD 8039

Open-headed type
- Shantung, Lettucy type

PAK CHOI

White-stalked type
- Large--Joi Choi, Prize Choi, What-A-Joy Choi, White Stalked

Green-stalked type
- Large--Chinese Pak Choi, Round-leaved Santung
- Small--Mei Qing Choi, Shanghai, Chinese Flat Cabbage (Tatsoi)

Details of management of soil and crops and pertinent dates are listed in Table 1.

Anomalies in rainfall and temperature affected development, bolting, and maturity of Chinese cabbage and pak choi in 1988 and 1989. In spring 1988, rainfall was 1 inch below normal. The average daily temperature at both sites was below 50 F on 20 of 30 days following transplanting the crop. In fall 1988, temperatures and rainfall were about normal. In spring 1989, rainfall was 6.7-7.8 in above normal from April 20 to May 30 at Mt. Carmel and Windsor. Temperatures were also cooler than normal. The average daily temperature was below 50 F at both sites on 22-23 of 30 days following transplanting of crop 1. Crop 2 was subjected to 12-14 of 30 days of below 50 F average daily temperatures within one month of transplanting. From July 15 through October 31, 24.2 inches of rain fell at Windsor and 22.7 inches fell at Mt. Carmel or 11.6 and 8.8 inches above normal for the period (Brumbach, 1965). Temperatures during fall 1989 were about normal.

TABLE 1--Soil and crop management of Chinese cabbage and Pak choi, 1988-1989

Activity		Spring Crop	Fall Crop
Soil Fertilization			
10-10-10		1000 lb/A	1000 lb/A
Ammonium nitrate		150 lb/A	150 lb/A
(Side dress 1 month after transplanting)			
Lime (to attain pH 6.5)		None	None
Planting Dates			
Seeding in greenhouse	1st crop	March 17-20	June 15
or outdoor enclosure	2nd crop	April 3	June 29
	3rd crop	-	July 18-22
Transfer to cold frame	1st crop	April 11-12	-
	2nd crop	April 26	-
Transplant seedlings to field	1st crop	April 21-24	July 12-16
	2nd crop	May 4-8	Aug 3-8
	3rd crop	-	Aug 17-22
Pest Control			
Root maggots (at planting)		Lorsban 4E	-
Flea beetles (on seedlings)		Pydrin 2.4F	Pydrin 2.4E, Sevin
Number of Irrigations			
Windsor		1	2
Mt. Carmel		0	2-3
Weed Control			
Cultivations		2	2

TABLE 2--Yield of Chinese Cabbage at Mt. Carmel and Windsor, Spring 1988

	Mt. Carmel			Windsor		
Cultivar**	Heads Hvst. %	Avg. Head lb	Total Yield* lb/A	Heads Hvst. %	Avg. Head lb	Total Yield* lb/A
Blues	100	2.0	19060	97	1.6	14750
Kasumi	100	2.0	19890	100	2.1	20510
Nerva	97	2.3	21460	47	1.7	7940
Springtime	97	2.4	22850	97	2.0	18920
Two Seasons	100	2.0	19340	100	1.7	16800

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*Based on 9680 plants/acre.

**Nagoda also tested at both sites - 85% bolted. All cultivars are Napa types.

TABLE 3--Yield of Chinese cabbage at Mt. Carmel and Windsor, Spring 1989

	Mt. Carmel			Windsor		
Cultivar**	Heads Hvst. %	Avg. Head lb	Total Yield* lb/A	Heads Hvst. %	Avg. Head lb	Total Yield* lb/A
First crop						
Blues	40	2.0	7940	73	2.4	17240
China Express	0	0	0	23	2.5	5550
Kasumi	13	2.5	3160	77	2.6	19040
Nerva	0	0	0	40	2.9	11330
Tip Top	0	0	0	30	2.0	5670
Two Seasons	20	2.3	4500	77	2.2	16830
Second crop						
Blues	77	1.9	14100	90	2.6	22510
China Express	0	0	0	80	2.5	19220
China Flash	0	0	0	77	2.6	19160
Kasumi	37	2.0	7220	93	2.6	23190
Nerva	0	0	0	30	2.9	8590
Two Seasons	53	1.6	8380	93	2.6	22990

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*Based on 9680 plants/acre.

**Arcadia, China Flash (First crop), Spring A-1, Springtime, Spring Triumph, Tip Top (Second crop), Tropical Shot and Wong Bok also tested at both sites - 88-100% bolted in each crop. All cultivars reported are Napa types.

YIELD AND QUALITY OF CHINESE CABBAGE

Spring crop - 1988.

The average yield of five cultivars was 43% greater at Mt. Carmel (20,520 lb/A) than Windsor (14,360 lb/A) (Table 2). At Windsor the lower average yield was due to smaller heads (1.8 lb compared to 2.0 lb at Mt. Carmel) and the high degree of bolting (53%) of Nerva. Smaller head size at Windsor was due to moisture stress in the sandy soil during the early stages of crop development. Eventually irrigation was required. Among cultivars, the yields of Springtime and Nerva at Mt. Carmel and Kasumi at both sites was near or above 20,000 lb/A. At both sites 95% of heads of all cultivars, except Nerva at Windsor, were marketable and had good quality. The compactness and closure of spring-grown heads was somewhat less than fall-grown heads because increasing temperature and daylength causes more rapid growth in spring.

Bolting was minimal, except for Nerva, because the well-drained soil warmed and prevented vernalization, despite 20 days in which average daily temperature was below 50 F.

Spring crop - 1989.

Extensive bolting occurred in crops 1 and 2 at Mt. Carmel and in crop 1 at Windsor. Vernalization, which causes bolting, can be induced by subjecting Chinese cabbage plants to temperatures below 50 F for 10-14 days (Lorenz 1946, Pressman & Negbi 1981). But the effect of air temperature on vernalization of Chinese cabbage can be decreased by soil warming and transfer of heat to the growing point (Rietze & Wiebe 1988) in well-drained soil. Rainfall in 1989 was well above normal from April 22 - May 30 at Mt. Carmel and Windsor and the loamy soil of Mt. Carmel was saturated most of the time and temperatures remained below the critical 50 F needed to vernalize, despite rising air temperature at the end of May. The sandy soil at Windsor, however, drained rapidly after excessive rains, permitted the soil to warm, and prevented vernalization of most of the cultivars in crop 2.

The severe weather in 1989 served to identify the cultivars that are most tolerant of cold and excessive moisture. In crop 1 at Windsor, yield of Blues, Kasumi and Two Seasons exceeded 16,500 lb/A; about 25% plants bolted (Table 3). At Mt. Carmel, only these cultivars among the 14 cultivars tested produced up to 40% marketable heads.

In crop 2, average yield of Blues, Kasumi and Two Seasons increased 78-128% at Mt. Carmel and 22-37% at Windsor. Bolting occurred in all plants of the other cultivars at Mt. Carmel. At Windsor, average yield of Blues, Kasumi and Two Seasons exceeded 22,000 lb/A with over 90% marketable heads. The average weight/head of these cultivars in both crops at Windsor was 2.5 lb, well above 1.8 lb in 1988, because moisture stress did not limit crop growth.

TABLE 4--Yield of Chinese cabbage at Mt. Carmel and Windsor, Fall 1988

	Mt. Carmel			Windsor		
Cultivar**	Heads Hvst. %	Avg. Head lb	Total* Yield lb/A	Heads Hvst. %	Avg. Head lb	Total* Yield lb/A
Blues	100	3.6	34850	100	3.2	31360
China Pride	97	2.6	24420	100	2.6	24930
Dynasty	97	3.7	35070	100	3.2	31060
Jade Pagoda (M)	97	3.0	28230	100	3.0	29020
Kasumi	100	2.7	26560	100	3.0	28980
Lettucy Type (O)	93	2.5	22510	100	3.7	35550
Monument (M)	100	2.2	21070	100	3.1	29750
Nagoda	97	3.2	30190	100	3.0	29420
Nerva	100	3.0	28740	93	3.8	33800
Springtime	100	2.9	28310	100	2.6	24820
Summertime	93	1.8	16317	93	2.9	26280
Two Seasons	100	2.9	28110	97	3.4	32160

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* Based on 9680 plants/acre.

** M = Michihli type; O = Open type; All others are Napa types.

Fall crop - 1988.

The average yield of all cultivars was the same at both sites; Mt. Carmel, 27,030 lb/A, and Windsor, 27,150 lb/A. The average fall yield exceeded the average spring yield by 32% at Mt. Carmel and 89% at Windsor. At both sites over 90% of all cultivars produced high quality marketable heads that averaged 3.0 lb (Table 4). At Mt. Carmel, Blues and Dynasty, two large-headed Napa types, yielded about 35,000 lb/A. Yield of Jade Pagoda, Nerva, Springtime, and Two Seasons exceeded 25,000 lb/A. At Windsor, yield of Lettucy type, (a loose, open-headed type) exceeded 35,000 lb/A. Unfortunately, this very mild tasting cultivar harbored many insects (mostly earwigs) that sought refuge in open heads on hot sunny days. There was no evidence of insect feeding. Yield of Blues, Dynasty, Nerva and Two Seasons exceeded 30,000 lb/A. Over 90% of all cultivars at Windsor produced marketable heads of high quality.

Fall crop - 1989.

Excessive rain in summer and early fall caused many heads to rot as they matured. At Windsor, 22%, 43% and

TABLE 5--Yield of Chinese cabbage at Mt. Carmel, Fall 1989

	Crop 1			Crop 2			Crop 3		
Cultivar**	Heads Hvst. %	Avg. Head lb	Total Yield* lb/A	Heads Hvst. %	Avg. Head lb	Total Yield* lb/A	Heads Hvst. %	Avg. Head lb	Total Yield* lb/A
Arcadia	73	3.0	21060	90	3.0	25830	93	4.0	36050
Blues	83	2.2	17360	93	3.3	29420	87	4.3	36120
China Express	70	2.6	17730	97	3.5	32740	-	-	-
China Flash	83	3.2	25350	83	3.0	24240	-	-	-
China Pride	80	3.3	25590	77	3.1	22770	-	-	-
Dynasty	70	2.9	19360	97	5.3	52840	87	6.8	57090
Early Top (G)	80	2.6	20290	70	3.2	21880	-	-	-
Green Rocket (M)	93	2.6	23450	97	2.2	20320	-	-	-
Jade Pagoda (M)	90	2.4	20790	87	3.2	27310	90	4.9	42690
Kasumi	60	2.5	14400	73	3.3	23370	93	5.2	47080
Magica	33	3.2	3190	87	3.4	28620	90	4.4	38580
Monument (M)	87	2.6	21820	100	3.0	29100	97	4.1	38450
Nagoda	67	2.6	16960	73	3.1	22080	90	3.7	32450
Nerva	70	3.4	23290	77	3.6	26490	90	4.2	36940
Shantung (O)	57	2.4	13100	73	1.6	11520	-	-	-
Springtime	63	1.9	11860	73	3.0	21140	-	-	-
Spring Triumph	70	3.7	25150	77	4.0	29490	-	-	-
Summertime	67	2.2	14490	83	2.9	23120	77	4.0	29730
Tropical Pride (G)	87	2.0	17110	90	2.5	21420	-	-	-
Tropical Shot (G)	0	0	0	10	1.0	970	-	-	-
Two Seasons	73	2.2	15960	90	3.0	26440	97	4.6	43370
VGO 8039 (M)	77	2.1	15940	87	2.6	21900	-	-	-
Winter Giant	40	3.9	15080	73	4.0	28410	67	4.6	30080
Wintertime	77	3.3	24890	90	3.6	30960	-	-	-
Wong Bok	27	4.3	11210	50	2.9	13920	-	-	-

* Based on 9680 plants/acre.

** G = Globular type; M = Michihli type; O = Open type; All others are Napa types.

22% of crops 1, 2, and 3 rotted, compared to 18%, 11%, and 5% at Mt. Carmel. The average yield of 12 cultivars common to crops 1, 2, and 3 at Mt. Carmel were 16,980 lb/A, 28,590 lb/A and 39,050 lb/A (Table 5) compared to 12,650 lb/A, 16,980 lb/A and 18,240 lb/A at Windsor (Table 6) The reduced yields at Windsor, 26-53% lower than Mt. Carmel, were attributed to greater losses by rotting and smaller heads due to leaching of nutrients by excessive rain. The progressive increase in average yield at both sites from crop 1 through crop 3 indicates that most cultivars responded well to mild temperatures and shorter days. Lower yield in crop 1 at both sites was due to fewer leaves forming the head during a shorter span to maturity.

Despite the low average yield of crop 1 at Mt. Carmel, several cultivars were notable. Yields of China Flash, China Pride and Spring Triumph exceeded 25,000 lb/A despite 20-30% rotting of heads (Table 5).

Yields of Arcadia, Early Top, Nerva and Wintertime exceeded 20,000 lb/A. Yields of Green Rocket, Jade Pagoda and Monument (all Michihli types) exceeded 20,000 lb/A and only about 10% of heads rotted. In crop 2 at Mt. Carmel, yields of 22 of 25 cultivars exceeded 20,000 lb/A. Dynasty, a large headed type, yielded most, 52,840 lb/A. Yields of China Express and Wintertime exceeded 30,000 lb/A but the heads of Wintertime were not firm and had poor closure at the top.

TABLE 6--Yield of Chinese cabbage at Windsor, Fall 1989

	Crop 1			Crop 2			Crop 3		
Cultivar**	Heads Hvst. %	Avg. Head lb	Total Yield* lb/A	Heads Hvst. %	Avg. Head lb	Total Yield* lb/A	Heads Hvst. %	Avg. Head lb	Total Yield* lb/A
Arcadia	93	1.3	11680	60	1.8	10590	80	2.7	20790
Blues	80	2.7	21070	73	3.1	21680	73	2.9	20360
China Express	70	2.5	16860	33	2.1	6950	-	-	-
China Flash	77	2.1	15540	63	2.4	14720	-	-	-
China Pride	83	2.3	18840	47	1.5	6800	-	-	-
Dynasty	93	3.1	28250	67	3.1	20230	67	3.7	24040
Early Top (G)	80	2.0	15190	50	2.5	12200	-	-	-
Green Rocket (M)	77	1.9	14420	90	1.8	15670	-	-	-
Jade Pagoda (M)	77	3.1	23090	50	2.2	10890	63	2.8	16810
Kasumi	90	2.3	20130	73	2.9	20360	90	2.8	24840
Magica	83	3.0	24280	50	1.2	6050	80	2.5	19660
Monument (M)	77	2.4	17880	73	1.7	12190	77	2.8	20820
Nagoda	57	1.8	9660	33	3.2	10220	47	2.4	11170
Nerva	77	2.9	21370	47	2.2	9970	80	2.3	17970
Shantung (O)	53	2.4	12160	30	1.2	3630	-	-	-
Springtime	93	2.3	21080	23	2.0	4570	-	-	-
Spring Triumph	87	2.7	22900	50	1.8	8850	-	-	-
Summertime	77	2.1	15370	27	2.4	6270	77	2.2	16590
Tropical Pride (G)	93	2.0	18210	70	1.9	12790	-	-	-
Tropical Shot (G)	27	0.9	3220	0	0	0	-	-	-
Two Seasons	83	1.9	15650	70	2.7	18610	93	3.2	29300
VGO 8039 (M)	70	1.4	9280	37	1.2	4400	-	-	-
Winter Giant	43	2.5	10450	27	1.8	4770	63	3.6	22290
Wintertime	57	1.9	10430	40	1.8	6780	-	-	-
Wong Bok	30	2.4	6860	13	1.4	1830	-	-	-

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* Based on 9680 plants/acre.

** G = Globular type; M = Michihli type; O = Open type; All others are Napa types.

In crop 3 at Mt. Carmel, the yields of virtually all cultivars exceeded 30,000 lb/A. Again, Dynasty had the greatest yield, 57,090 lb/A. Its very large head, often exceeding 10 lb, may confine its marketability to restaurants or institutions.

In crop 1 at Windsor, Dynasty had the greatest yield, 28,250 lb/A (Table 6). Yield of Blues, Jade Pagoda, Kasumi, Magica, Nerva, Springtime, and Spring Triumph exceeded 20,000 lb/A despite 7-23% loss of rotted heads. In crop 2, only the yield of Blues, Dynasty and Kasumi exceeded 20,000 lb/A and 27-33% of heads rotted compared to an average of 43% for all others. Although the yields of China Flash and Two Seasons were less than 20,000 lb/A, 63-70% of the heads were marketable. In crop 3, the yields of 7 of 10 cultivars exceeded 20,000 lb/A. Dynasty, Kasumi and Two Seasons yielded most.

Maturity.

Maturity of Chinese cabbage is important in scheduling planting for a specific harvest. The days to maturity were calculated from the day of transplanting to the day when half the heads were harvested. Chinese cabbage tends to mature uniformly so that the crop can be harvested in one cutting. In spring and fall trials, 70-100% of each cultivar was harvested in the first cutting and the remainder 7-10 days later. The days to maturity is dependent upon daylength and weather. In 1988, the average maturity of Blues, Nerva, Kasumi and Two Seasons was 44 days for plants harvested in June and 42 days for plants harvested in mid-September. In 1989, cold and wet weather delayed maturity about 11 days compared to 1988. Average maturity of the same four cultivars for two spring and three fall crops was 55, 50, 38, 53, and 57 days. The maturity of Chinese cabbage was highly responsive to photoperiod. In late spring and summer, plants matured rapidly and tended to bolt, thus yield was reduced. Prompt harvest of mature cabbage was important. Delaying harvest for 7-10 days reduced the percent of marketable heads. In fall, with decreasing daylength and temperature, days to maturity and head weight increased. Some cultivars planted late in August at Mt. Carmel were held in the field as long as 3 weeks beyond maturity without decreased head quality. Although maturity after transplanting varied because of differences in weather and daylength throughout the season, the cultivars can be grouped as follows:

Early (less than 55 days)
Arcadia, China Flash, Early Top, Kasumi, Nagoda, Nerva, Spring A-1, Tropical Pride Tropical Shot, and Two Seasons.

Middle (55-65 days)
Blues, China Express, China Pride, Dynasty, Green Rocket, Lettucy type, Magica, Shantung, Springtime, Spring Triumph, Summertime, Tip Top, and VGD 8039

Late (greater than 65 days)
China Pride, Jade Pagoda, Monument, Winter Giant, Wong Bok.

Maturity of cultivars planted after May 1 and before July 30 was 5-10 days shorter than those planted in April and August.

YIELD AND QUALITY OF PAK CHOI

Spring crop - 1988. The average yield of three Pak choi cultivars was 21% greater at Mt. Carmel (19,500 lb/A) than Windsor (16,050 lb/A). Prize Choi, a cultivar with white petioles, yielded most among all cultivars at both sites. At Mt. Carmel (27,550 lb/A) yield was 47% greater than at Windsor (18,720 lb/A) (Table 7). Yield of Chinese Pak Choi, a cultivar with pale green petioles was virtually the same at both sites. The yield of Mei Qing Choi, a cultivar with broad, green, spoon-shaped petioles, was 10% greater at Mt. Carmel than at Windsor. At both sites, the average yield of Mei Qing Choi was 26 to 73% less than the yield of Chinese Pak Choi and Prize Choi. Low yield of Mei Qing Choi was due to its inherent small size. Virtually all plants at both sites were marketable with excellent quality.

Spring crops - 1989.

Pak choi trials were expanded in 1989 to 11 cultivars and two crops planted 14 days apart. Cool temperatures and saturated soil caused severe bolting and reduced yields of all but four cultivars. All plants of five cultivars bolted at both sites (Footnote, Table 7). Poor yields of Mei Qing Choi and Chinese Flat Cabbage (Tatsoi) indicated sensitivity to cold. Despite adverse conditions, Chinese Pak Choi, Joi Choi, Prize Choi and What-A-Joy Choi yielded fairly well at both sites with more than 80% marketable plants. The average yields at Mt. Carmel and at Windsor differed by only 3% (Table 7). In the second crop, however, average yield of the same four cultivars was 28% greater at Mt. Carmel compared to Windsor. The lower yields at Windsor in the second crop were due to leaching of nutrients in the sandy soil during heavy rains, despite a side-dressing of ammonium nitrate. Among all cultivars, Joi Choi and What-A-Joy Choi consistently yielded most. These white-stalked cultivars had excellent quality.

Fall crop - 1988.

The average yield of all cultivars was 24,520 lb/A at Mt. Carmel and 22,750 lb/A at Windsor, a difference of 8% (Table 8). The average yield in fall compared to spring

TABLE 7--Yield of Pak choi at Mt. Carmel and Windsor, Spring 1988-1989

	Mt. Carmel			Windsor		
Cultivar**	Plants Hvst. %	Avg. Plant lb	Total Yield* lb/A	Plants Hvst. %	Avg. Plant lb	Total Yield* lb/A
1988						
Ch. Pak Choi	100	1.8	16940	97	1.8	16740
Mei Qing Choi	100	1.4	14000	100	1.3	12700
Prize Choi	100	2.8	27550	100	1.9	18720
1989--Crop 1						
Ch. Flat Cabbage	13	1.0	1280	7	0.6	380
Ch. Pak Choi	93	1.4	12760	100	1.5	14960
Joi Choi	100	1.9	18290	97	1.8	16570
Mei Qing Choi	0	0	0	43	1.2	4980
Prize Choi	83	1.3	10580	93	1.2	11290
What-A-Joy Choi	87	1.9	16170	100	1.7	16540
1989--Crop 2						
Ch. Flat Cabbage	0	0	0	30	0.8	2220
Ch. Pak Choi	90	1.4	12280	87	1.0	8140
Joi Choi	97	1.9	17970	93	1.5	13340
Mei Qing Choi	0	0	0	0	0	0
Prize Choi	77	1.3	9340	67	1.6	10720
What-A-Joy Choi	90	2.2	19120	93	1.5	13680

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* Based on 9680 plants/acre.

** Bok Choi-Short, Hung Chin, Shanghai, Spoon Cabbage, and White Stalked also tested at both sites in 1989 - 100% bolted in both crops.

TABLE 8--Yield of Pak choi at Mt. Carmel and Windsor, Fall 1988

	Mt. Carmel			Windsor		
Cultivar**	Plants Hvst. %	Avg. Plant lb	Total Yield* lb/A	Plants Hvst. %	Avg. Plant lb	Total Yield* lb/A
Ch. Pak Choi	100	2.9	28080	97	2.3	21750
Mei Qing Choi	100	1.7	16420	100	1.9	18760
Prize Choi	100	3.0	29040	100	2.9	27750

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* Based on 9680 plants/acre.

was 26% greater at Mt. Carmel and 41% greater at Windsor (Table 7). The lower yields in spring were attributed to fewer days to maturity in response to warming temperatures and longer daylengths. Prize Choi yielded most at both sites. The low yields of Mei Qing Choi at both sites were due to its inherent small size. Virtually all plants of Pak choi at both sites were marketable and had excellent quality.

Fall crops - 1989.

In fall 1989, 11 cultivars were tested in each of three crops planted 14 days apart. Similarly to Chinese cabbage, several Pak choi cultivars were severely damaged by excessive rainfall in August and September. At Windsor 36% and 37% of crops 2 and 3 rotted in the field. In comparison, only 18% and 24% of crops 2 and 3 rotted at Mt. Carmel. All plants of Bok Choi-Tall, Hung Chin and White Stalked Choi bolted in crop 1 and crop 2 at both sites and were excluded from crop 3. Most plants of Shanghai bolted in crops 1 and 2, and it also was excluded from crop 3.

Comparing only those cultivars common to all three fall crops, the average yield of Chinese Pak Choi, Joi Choi, Mei Qing Choi, Prize Choi and What-A-Joy Choi at Mt. Carmel was 19,310, 17,646, and 18,610 lb/A for crops 1, 2, and 3, respectively (Table 9). The lower average yields of crops 2 and 3 compared to crop 1 was due to 18-24% loss of the crops to crown rot, compared to 11% loss in crop 1. The yields of Joi Choi and What-A-Joy Choi consistently exceeded 23,000 lb/A in all three crops and losses of plants to rot were 10% or lower.

At Windsor, the average yields of the same five cultivars were 21,640, 8,700, and 13,580 lb/A for crops 1, 2, and 3. In crops 2 and 3, 40 and 37% of the crop was lost to crown rot compared to only 5% loss in crop 1. The yields of Joi Choi and What-A-Joy Choi were above 20,000 lb/A for crops 1 and 3 but fell to 12,000 in crop 2. Crown rot and decreased plant size due to leaching of nutrients by heavy rains reduced yield. The average plant weight of Chinese Flat Cabbage (Tatsoi), Mei Qing Choi and Shanghai Choi was less than all others due to their inherent small size.

TABLE 9--Yield of Pak choi at Mt. Carmel and Windsor, Fall 1989

	Crop 1			Crop 2			Crop 3		
Cultivar**	Plants Hvst. %	Avg. Plant lb	Total Yield* lb/A	Plants Hvst. %	Avg. Plant lb	Total Yield* lb/A	Plants Hvst. %	Avg. Plant lb	Total Yield* lb/A
Mt. Carmel									
Ch. Flat Cabbage	90	0.8	7380	83	1.4	11010	-	-	-
Ch. Pak Choi	93	1.8	16500	93	1.5	13300	87	2.4	20590
Joi Choi	93	2.7	24480	90	2.7	23190	87	2.4	19800
Mei Qing Choi	93	1.6	14670	83	1.2	9800	33	1.2	3910
Prize Choi	77	2.3	17300	80	2.1	16720	77	3.1	23390
Santung	67	1.6	10240	27	2.3	6000	-	-	-
Shanghai	27	1.4	3600	60	1.1	6470	-	-	-
What-A-Joy Choi	87	2.8	23600	97	2.7	25220	97	2.7	25360
Windsor									
Ch. Flat Cabbage	97	1.2	11050	87	0.9	7250	-	-	-
Ch. Pak Choi	100	2.0	19860	73	1.0	7030	60	1.7	9700
Joi Choi	100	2.6	24910	60	2.0	11500	90	2.7	23410
Mei Qing Choi	90	2.0	17300	63	1.1	6840	20	1.3	2580
Prize Choi	90	2.4	20650	37	1.5	5620	64	2.0	12150
Santung	80	2.4	18690	40	1.5	5690	-	-	-
Shanghai	50	1.7	8090	44	0.5	2300	-	-	-
What-A-Joy Choi	97	2.7	25480	67	1.9	12520	80	2.6	20030

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* Based on 9680 plants/acre.

** Bok Choi-Tall, Hung Chin, and White Stalked also tested - 100% bolted in Crops 1 and 2.

Maturity.

In spring trials, 80-100% of each cultivar was harvested in the first cutting and the remainder 4-7 days later. In fall trials, all cultivars were harvested in one cutting. The days to maturity was dependent upon daylength and weather. In 1988, the average maturity of Chinese Pak Choi, Mei Qing Choi and Prize Choi was 38 days in spring and 40 days in fall. In spring 1989, both crops of Pak choi planted for harvest in early June at Mt. Carmel and Windsor matured in 41-42 days, or about 3 days longer than 1988. Heavy rains and persisting cold soil in 1989 increased the maturity. The average maturity of cultivars in crop 1 planted July 12-17 for harvest in mid-August was 45 days at Mt. Carmel and only 28 days at Windsor. Although July temperatures were warm at both sites, excessive rains at Mt. Carmel periodically saturated the loamy soil and the plants grew and matured more slowly. At Windsor, where rainfall was normal, the plants grew rapidly and matured within a month of transplanting. Crop 2, harvested in mid September, matured in 41-44 days at both sites. Crop 3, harvested in mid-October, matured in 49-51 days as temperatures cooled and daylength shortened. Although maturity during the season varies with temperature and photoperiod, differences among the cultivars within each crop seldom varied more than 2-3 days.

PLANTING AND HARVESTING STRATEGY

Planting strategies for Chinese cabbage and Pak choi are clear. Unlike broccoli and cauliflower with broad ranges in maturity and harvest spans (Hill 1989), maturity and harvest span of Chinese cabbage and Pak choi tested in 1988 and 1989 varied about 10 days. Thus, multiple cropping seems to be the most practical strategy.

I have demonstrated that plantings of Chinese cabbage and Pak choi late in April and early in May produced satisfactory yields in June. Selection of cultivars that resist bolting in spring is highly important for plantings in late April. Chinese cabbage cultivars Blues, Kasumi, and Two Seasons provided satisfactory marketable yields in 1988 and 1989. The only exception was on crops grown on loamy soil subjected to above normal rainfall. For May plantings, Springtime, China Express and China Flash also provided excellent yield and quality.

Pak choi cultivars Joi Choi and What-A-Joy Choi provided satisfactory yield and quality in late April and early May plantings. Since Pak choi matured in 4 weeks after transplanting, a possible third spring planting in late-May can be explored for late June harvest.

Mid-July plantings for harvest in mid-to-late August had highest yield and quality from Blues, China Pride, Dynasty, Jade Pagoda, Monument, Nerva and Spring Triumph. For August plantings to be harvested in September and October, Arcadia, Kasumi, Magica and Two Seasons also provided satisfactory yields.

For Pak choi in fall, Joi Choi, Mei Qing Choi, Prize Choi and What-A-Joy Choi provided the highest yield and quality in plantings from mid-July to mid-August.

Strategy for harvest is also clear. Chinese cabbage and Pak choi planted for spring harvests are prone to bolting as daylength increases. The plants should be harvested as soon as the plants reach marketable size. Delay in harvest in as little as 7 days may result in loss of yield and quality. In fall, as daylength decreases, danger of bolting lessens substantially. Most cultivars of Chinese cabbage and Pak choi could be held in the field for 2-3 weeks without loss of yield and quality.

In short, excessive rainfall in spring prolongs cold soil temperatures and with increasing daylength increases bolting. Excessive rain in summer and early fall promotes outbreaks of head rot. I have demonstrated, however, that high yields of marketable quality Chinese cabbage and Pak choi can be attained in spring and fall plantings by use of proper cultivars that resist bolting and disease.

REFERENCES

Anon. 1972. Nutritive value of foods. U.S.D.A. Home and Garden Bulletin No. 72.

Brumbach, J.J. 1965. The climate of Connecticut. Bull. 99. State Geological and Natural History Survey of Connecticut 215 p.

Hill, D.E. 1989. Cauliflower and broccoli trials - 1988. The Connecticut Agricultural Experiment Station, New Haven, Bulletin 869. 18 p.

Lorenz, O.A. 1946. Response of Chinese cabbages to temperature and photoperiod. Proceedings of American Society for Horticultural Science 47:309-319.

Pressman, E. & Negbi, M. 1981. Bolting and flowering of vernalized Brassica pekinensis as affected by root temperature. Journal of Experimental Botany 32:821-825.

Rietze, E. & Wiebe, H.J. 1988. The influence of soil temperature on vernalization of Chinese cabbage. Journal of Horticultural Science 63:83-86.

Yamaguchi, M. 1983. World vegetables: principles, production and nutritive values. AVI Publishing Company, Westport, Connecticut. 415 p.

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